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Hohlraum Energetics Campaign Activates NIF Hohlraum Drive Capability

In September 2004, an international team validated the National Ignition Facility (NIF) as a premier facility for performing hohlraum energetics experiments while concurrently activating new optical and x-ray diagnostics and techniques. Using the first four NIF laser beams (see Fig. 1), we demonstrated 300-eV NIF ignition-relevant hohlraum-radiation temperatures. We also demonstrated a steady long-drive capability unattainable on previous laser facilities (Fig. 2), which is useful for a variety of ignition and high-energy-density physics experiments.

During the campaign, single-ended, vacuum hohlraums were irradiated for the first time on NIF using its first quad of 3ω (0.35-µm wavelength) beams with up to 16 kJ of energy in flat-top pulse shapes ranging from 1 to 9 ns in duration. The laser beam foci were spatially smoothed and tailored using a combination of phase plates and birefringent crystals, which conditioned medium-range spatial nonuniformities to produce 300–500-µm diameter spots with average peak intensities between 10^{15} and 10^{16} W/cm^2. The hohlraums measured 0.6, 1.2, 1.6, and 2.4 mm, and were fabricated from 3–5-µm-thick gold walls to make them transparent to >8 keV x-rays (see Fig. 1a).

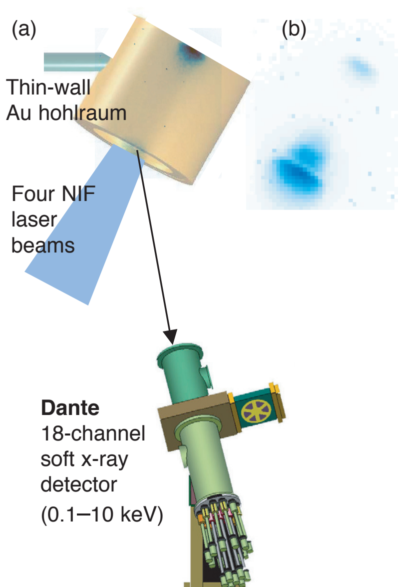

Figure 1. (a) Laser and hohlraum configuration showing one of the principal diagnostics (Dante) and overlaying a hard x-ray image showing the interaction between laser and back of the hohlraum wall at t = 2 ns. (b) A later image at t = 4 ns showing increased emission near the laser entrance hole.

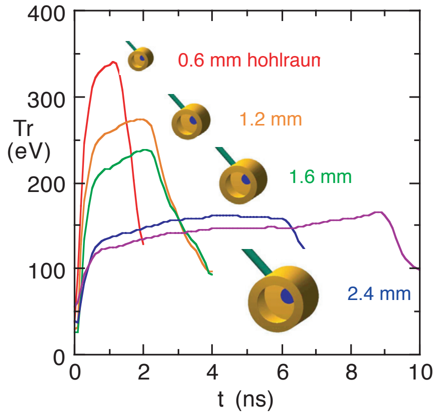

Figure 2. Measured hohlraum radiation temperature versus time for various size hohlraum sizes and pulse lengths.

The hohlraums were aligned to 50 µm relative to the laser beams and the target chamber center. The irradiated hohlraums were diagnosed by multiple x-ray diagnostics, including Dante, a soft x-ray (0.1–10 keV) power diagnostic, the Filtered Fluorescer (FFLEX) hard x-ray (20–100 keV) spectrometer for hot electron inference, and the FXI/HXRI hard x-ray (8–20 keV) 100-µm, 100-ps resolution multiple-frame camera for imaging the hohlraum laser plasmas. The FFLEX was developed in collaboration with England's Atomic Weapons Establishment (AWE). The Full-Aperture Backscatter System (FABS) and Near-Backscatter Imager (NBI) optical diagnostics measured energy-, time-, and spectrally resolved laser optical backscatter.

Up to three shots per day were fired, and all shots returned excellent data. The excellent match between preshot peak radiation temperature predictions and data (Fig. 3) to within the 2–3% of Dante measurement error bars are consistent with excellent coupling between laser and vacuum hohlraum, as supported by the optical backscatter and hard x-ray imaging and spectrometer data. The technique of hard x-ray radiography through hohlraum walls was extended to even thicker 25-µm Au walls on later gas-filled hohlraums shot by Los Alamos National Laboratory (LANL) scientists. The longer pulse drives also successfully validated modeling of the onset of vacuum hohlraum plasma filling, which leads to migration of the laser energy deposition region to the laser entrance hole as seen by the hard x-ray imager (Fig. 1b), and an increase in flux as seen by Dante late in time (Fig. 2, 9-ns pulse).

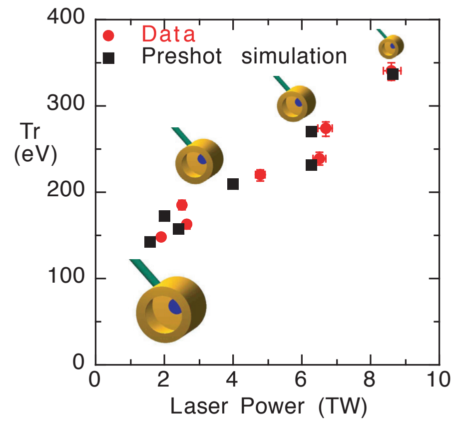

Figure 3. Comparison of measured vs. preshot simulation of peak radiation temperature vs. laser power for vacuum hohlraums driven by flat-top pulses.

The campaign included experimental physicists and target design scientists from Lawrence Livermore National Laboratory, LANL, Sandia National Laboratories, AWE, and France's Commissariat a l'Energie Atomique, as well as laser scientists, engineers, and technicians from the NIF Project, the National NIF Diagnostics Program, N Program, and Bechtel Livermore operations.

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